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BUREAU OF MINES
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COAL-MINE MECHANIZATION AND ACCIDENT-FREQUENCY RATES OF HAND AND MECHANICAL LOADING IN ILLINOIS

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A. U. MILLER

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

COAL-MINE MECHANIZATION AND ACCIDENT-FREQUENCY RATES OF HAND AND MECHANICAL LOADING IN ILLINOIS[1]

A. U. Miller[2]

INTRODUCTION

The term "mechanized mining" as used today by mining men of Illinois refers mainly to mechanical loading; however, in the fullest sense, mine mechanization has been in progress in Illinois for many years. To show the extent of this progress a brief history of mining in the State is given.

The first discovery of coal on the North American Continent is thought to have been made in what is now the State of Illinois. Authorities differ as to when and by whom this discovery was made. The World's Cyclopedia and Dictionary of Universal Knowledge gives this honor to Father Hennepin, who indicated a coal mine on the Illinois River near the present site of Ottawa, La Salle County, on a map published in 1698.

According to Mineral Resources of the United States (pt. 2, 1913, p. 332):

> The first mention of coal in the territory which afterwards became the United States is contained in the Journal of Father Hennepin, published in 1698. The Journal contains a map on which is marked "cole mine" on the banks of the Illinois River near the site of the present city of Ottawa, Hennepin having passed through this region 30 years before, in 1668.

The first record of coal mining in Illinois is in 1810, when coal was mined from the outcrop along the bluffs bordering on the Big Muddy River in Jackson County, a few miles below Murphysboro. A flatboat was loaded with coal that year and taken to New Orleans.

The Journal of the Franklin Institute for 1836 (quoted in Mineral Resources of the United States 1913, p. 832) states:

> The first actual mining operations conducted by white men were at Mount Carbon near Brownsville in Jackson County on the

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[1] The Bureau of Mines will welcome reprinting of this article, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7063."

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banks of the Big Muddy River, a short distance from its junction with the Mississippi. These mines were opened in 1810 and worked for a limited extent for many years.

The next record is that in 1832 several flatboats loaded with coal were sent to the New Orleans market. Doubtless coal was mined between 1810 and 1832 but to a limited extent as the demand was confined almost exclusively to the blacksmith trade.

The mining of coal for domestic use began in St. Clair County in 1832. Some coal was also mined in that year in Peoria, Rock Island County, at La Salle, and at other points. In 1833, 6,000 tons were hauled in wagons from Belleville, Ill., to St. Louis, Mo.

In 1833 the Government began recording the production of coal. The records show that production in Illinois increased from 6,000 tons in 1833 to 15,038 tons in 1839. The report for 1840 shows that 16,967 tons were produced in 19 counties by 152 employees; St. Clair County had the largest production - 5,196 tons. Production increased from 35,000 tons in 1841 to 400,000 tons in 1855.

In the early days coal was mined on the outcrop of the beds along the bluffs of rivers and streams. M. M. Leighton, chief geologist, State Geological Survey, in an article printed in the April (1929) issue of the Illinois Journal of Commerce says:

> It was only after drilling that coal was discovered away from streams and outcrops, but this did not happen until the population had extended inward and the need of water wells arose.

When the demand for coal exceeded the capacity of the mines along the outcrop, it was necessary to sink shafts to the coal beds. However, the sinking of shafts was delayed largely because of lack of transportation facilities. The first railroad in the Mississippi Valley, built in 1837 by a company organized by Governor Reynolds, connected the mines along the bluffs with a point opposite St. Louis, a distance of 6 miles.

At the close of 1849, 52 miles of railroad had been completed. In 1850 railroad construction began in earnest, and by the close of that decade 2,781 miles had been completed. Shaft mining was begun at Duquoin, Perry County, shortly after the Illinois Central Railroad was completed in 1855; within 10 years the coal fields of Alton, Kingston, Rock Island, Braidwood, and Braceville were developed. Shaft mining increased the production of coal from 410,000 tons in 1856 to 6,720,000 in 1881.3/

Beginning with 1882, yearly reports were made to the State Bureau of Labor Statistics, until the Civil Administrative Code, passed in 1917, placed all subjects relating to mining under the jurisdiction of the Department of Mines and Minerals.

3/ The historical data were taken from the Compilation of Coal Reports, published by the Illinois State Department of Mines and Minerals.

The report for 1882 shows that 43 counties produced coal. There were 704 mines, of which 207 were "steam shafts", 140 "horsepower" shafts, 9 steam slopes or shafts, and 329 other slopes or drifts. The annual reports show that the industry expanded from 9,115,661 tons with 20,290 men employed in 1882 to 89,979,469 tons with 91,372 men employed in 1918. Although 1918 was the peak year for production the peak year for employment was 1923, when 103,566 men were employed.

ACKNOWLEDGMENTS

The writer wishes to thank James McSherry, director, State Department of Mines and Minerals, officials and others of coal companies, and John E. Jones, safety engineer, Old Ben Coal Corporation, for their assistance in compiling the data in this paper.

EARLY USE OF MACHINERY

As mining operations advanced inland from the outcrops and the greater part of the tonnage was produced from shaft mines, the problems and hazards of mining, such as supervision of large groups of men underground, roof control, haulage, ventilation, coal dust, gases, explosions, mechanical equipment, use and handling of explosives, transportation of men and materials, etc., increased.

In the early days coal was mined by hand, the production per man depending upon the strength, ability, and desire of the employee to work while at the face. The opinion of many mining men at that time was that it was impossible for machinery to reduce hard manual labor. However, mining, like other industries, had to change to progress. It had to respond to the new ideas, practices, and methods of working that are the fundamentals of progress. Fortunately, some mining men believed that mining would respond to new ideas and practices, and as a result there is a vast difference in the methods and practices used today compared with those of the early days.

The following statement is made on page 143 of Roy's History of Coal Miners of the United States:

> In 1875 a coal cutter, called the "Butler" and later the "Harrison", was introduced in the mines of the Diamond Coal & Mining Co. in the State of Illinois, which, after a few defects in its make-up were remedied, held its own against the miner's pick. It did no more than hold its own, however, as there were many first-class underground workmen who could undercut more coal in a competitive trial than the iron miner.

Shortly after cutting machines were introduced in 1875 they were intalled in a number of mines. The subsequent comments were similar to those eard today regarding new ideas and practices, namely, that they would not e successful.

Reports of some inspectors for 1882 show that cutting machines had been installed in mines and then abandoned. The State Bureau of Labor Statistics

Report (p. 81) for that year states that the inspector for St. Clair County reported on the use of cutting machines in his district as follows: "They are considered unsafe on account of the noise they make which prevents the men from hearing any movement on the roof and anticipating a fall." On page 30 of the 1882 report another inspector reported that "the iron men (cutting machines) had been tried and failed in every instance." However, on page 122 of this report (1882) another inspector reported that in his district "the Harrison compressed-air cutting machine was being used successfully and was one of the valuable inventions of mining machinery of the day." Page 434 of the coal report for 1884 contains the following statement regarding machinery: "The Harrison mining machine is in successful operation in one of the shafts of the C. W. & V. Coal Co. Sixteen machines are employed, and they are cutting an average of about 600 tons daily. The mine is given over to machinery and no hand work is done except in the entries." Probably the first instance of the use of the term "mechanized mine" in connection with an Illinois mine was in this report.

The coal report for 1886 was the first to mention the number (235) of cutting machines in use. Beginning with 1888 the annual reports give the number used and tonnage undercut. The report for 1888 states that 272 cutting machines were in use in 38 mines and undercut 2,243,216 tons of coal. The use of cutting machines increased steadily from 1888 to 1923, the peak year, when 3,049 were used in 241 (65.5 percent) of the mines and undercut 51,057,868 tons (70.4 percent of the output of the State). In 1937, 103 (61.3 percent) of the mines used 927 cutting machines and undercut 92.3 percent of the production of the State.

From 1875 to 1890 undercutting machines were operated with compressed air. The coal report for 1890 states that cutting machines operated by electricity were being tried but were not successful. The report for 1892 (p. 475) states that all cutting machines in the State are operated by compressed air except the "Sperry", which was the first to use electric current. Since 1892 the use of electricity to operate cutting machines has increased steadily. The writer does not know of any cutting machines operated by other than electric power today, unless some are operated by compressed air in small local mines. Probably the last large company to use compressed-air machines in the State was situated at Mt. Olive. These machines were abandoned in 1930.

In the early days shot holes for blasting coal were drilled by hand with a "churn drill." As mining progressed the hand machine drill with an auger appeared, but very little information is available regarding its develc ment and use. The 1888 coal report (p. 427) states that "drillers are furnis ed with air drills or patented hand drills" and that "one mine had 36 air drills and about 67 patented hand drills." In hand-loading mines today very few, if any, shot holes are drilled with a "churn drill"; all miners use a patented hand drill of some type. With the advent of mechanical loading the electrical drill was introduced, and although no statistics are available as to the number in use, usually there is at least one electric drill for each mobile loading machine and one for about eight conveyor-type pit-car loaders.

With the development of shaft mines the transportation of coal to the shaft bottom became one of the major problems. In the early days small cars with a capacity of a few hundred pounds were pushed by hand on wooden rails to the shaft bottom. Later, 12-pound iron rails were introduced, and today some mines in the State have installed 90-pound rails on the main haulage. The size of mine cars has also increased. Many larger mines have cars with a capacity of 5 tons, and one mine will soon install a car having a capacity of 14 tons.

As the length of haul increased, dogs, ponies, horses, mules, tail ropes, cables, and gasoline and electric locomotives were introduced as power in the transportation systems of mines. The first electric locomotive installed in an Illinois mine was developed by Elmer E. Sperry and operated in mine 3 of the C. W. V. Coal Co. at Streator in 1888.[4]

Page 32 of the Compilation of Coal Reports, published by the State Department of Mines and Minerals of Illinois, contains the following statement: "The 1891 Coal Report contains the first reference to underground locomotive haulage. Here it is stated that in Livingston County the C. W. & V. Coal Co., at its No. 3 mine, had been experimenting with an electric locomotive, but up to the end of the year it was only partially successful." In 1900 seven mines used electric-locomotive haulage. Other methods of haulage that year were: Cables, 27 mines; horses or mules, 512 miles; and hand, 374 mines.

Beginning with 1907 the coal reports give the number of locomotives in use and the tonnage hauled. During 1907, 75 (18.3 percent) of the mines used 129 locomotives and hauled 16,542,575 tons (35.6 percent of the total production). The use of electric locomotives increased from year to year. The coal reports show that 1918 was the peak year for tonnage hauled, when 240 (64.8 percent) of the mines used 960 locomotives which hauled 77,662,619 tons (88 percent of the production for the year). The peak year for number of mines and locomotives used was 1923, when 285 (77.4 percent) of the mines operated 1,547 locomotives which hauled 70,863,815 tons (97.7 percent of the total production for the year). In 1937, 84.1 percent of the mines used 1,288 electric locomotives which hauled 98.5 percent of the total output for the year. Today some of the largest producing mines operate 40 to 65 locomotives during a regular working shift.

PROGRESS OF MECHANICAL LOADING

The progress of mechanical loading in Illinois mines, like that of other mechanical equipment mentioned, has been gradual. Many types of conveyors, pit-car loaders, and mobile loaders were tried, some of which proved successful. Formerly it was not unusual to see discarded mechanical loading equipment stored in unused workings underground or on the surface.

One of the first recorded dates for mechanical loading is 1888, when a Stanley" entry driver was brought from England and tried at Francisville coal mine near Colorado Springs, Colo.

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[4] Stoek, H. H., Fleming, J. R., and Haskins, A. J., A Study of Coal Mine Haulage in Illinois: Univ. Illinois Bull. 132, 1922, p. 25.

In 1890 a "Stanley Header" with conveyor was tried at the Bennett mine, Lebanon, Ill.

In 1903 a coal loader, designed by W. E. Hamilton, was installed by the Big Muddy Coal Co., Dewmaine, Ill.

In 1921 the C. W. F. Coal Co., West Frankfort, Ill., installed loading machines. On July 9, 1924, the C. W. F. Coal Co. made the first local Illinois wage agreement. Under this agreement it was possible to do experimental work with loading machines. The first State of Illinois wage agreement for loading machines was made September 16, 1928.5/

Experiments with loading machines continued, but apparently data were not assembled as to the number and kind in use, the tonnage produced, or the first mine that adopted complete mechanical loading.

The 1927 Coal Report is the first to give information on the number of loading machines used and the tonnage produced. During this year 21 (9.3 percent) of the mines operated 129 loading machines, which produced 1,657,853 tons (3.9 percent of the yearly output). In 1930, 69 (40 percent) of the mines operating used 2,238 loading machines and loaded 23,250,031 tons (50.8 percent of the tonnage mined in the State). The peak year for loading machines was 1931 when 74 (49 percent) of the mines used 2,414 loading machines and loaded 22,445,804 tons (61.4 percent of coal mined in the State). During 1937, 69 (41.1 percent) of the mines used 1,456 loading machines and loaded 28,374,362 tons (59 percent of the total output).

The general use of one source of power for mechanical equipment usually results in the installation of other types of equipment using the same power. After electricity became an important factor in mine operation, in addition to the equipment mentioned, underground motor generator sets, rotary converters, switchboards, circuit breakers, transformers, lighting and telephone lines, concrete mixers, welding units, motor-driven pumps, machine shops, rock-dusting machines, automatic track switches and signals, ventilating fans air compressors, and many miles of trolley and other feeder lines were installed.

Not only has the use of underground mechanical equipment increased decidedly but also the use of machinery on the surface. Many coal companies have installed well-equipped machine shops where both underground and surfac machinery is overhauled and rebuilt, also large power and transformer statio with necessary accessories. The cleaning and preparation of coal have becom important parts of the industry and have resulted in the construction of washers and large well-equipped tipples for sizing and preparing coal.

According to published data the mechanization of Illinois mines starte when coal-cutting machines were first introduced in 1875, or about 63 years ago. From 1875 to date the introduction of mechanical equipment has been

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5/ The historical data pertaining to the introduction of loading machines were taken from the 1929 Year Book issued by the American Mining Congres gradual. Today many different types of mechanical equipment are used underground and on the surface in the production and preparation of coal; therefore the term "mechanization" refers to other equipment than loading machines.

HAZARDS OF MECHANICAL EQUIPMENT

There has been considerable discussion during different periods as to whether or not mechanical equipment increases the accident hazard and is responsible for a higher accident rate. At present, discussions of the relative advantages of hand and mechanical loading are frequent.[6] To make a just comparison of the accident rates of hand and mechanical loading would be difficult, if not impossible, as there is a large difference in the operating conditions of each method. Some commendable practices and some that should be condemned are followed in each method.

With hand loading the miner does not have to contend with the noise and vibration of loading machines. The hand loader has been virtually the "boss" of his working place and has maintained it largely as he pleases. He can sound the roof often, timber the roof well, and adopt other safe practices if he so desires. However, reports of many accidents in the State indicate that this has not been done. In hand-loading mines many foremen have 75 to 200 men, scattered over a large area, working under their supervision. It is impossible for a foreman to supervise closely so many men and attend to his other duties. As some mine workers, like some workers in other industries, are careless and indifferent, unquestionably the lack of good supervision has been responsible for many accidents in hand-loading mines.

Mechanical equipment, whether cutting, loading, drilling, or other types f machines, undoubtedly increases the mechanical, electrical, and other azards if proper precautions are not observed and practices and methods of orking changed to suit conditions. The noise and vibration of the machinery revent workers from hearing roof "working", and it is almost certain that ibration of the machinery affects loose roof. In the early days of echanical loading there was a tendency to neglect systematic timbering and ounding of roof, as well as other safe mining practices; to some extent this eglect still exists. As a number of men frequently are working at the face t one time, the hazard from roof falls is increased. If a large fall should cur it is more likely to kill or injure two or more men at one time, and his has occurred. Increased use of mechanical loading equipment also introduces other hazards.

Other phases of mechanical loading should tend to lower the accident te. With mechanical loading a foreman may have the 15 to 50 men under his rvision concentrated in a small area. He can then supervise them and the strict closely and observe and remedy unsafe practices and conditions latively promptly, which will be an important factor in the prevention of cidents. The efficiency of 15 to 20 men may be involved in the operation one mobile loading machine, which if it is to operate satisfactorily will

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The term "mechanical loading" as used in this paper includes mobile loaders, pit-car loaders, and conveyors.

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require better track and rolling stock, closer inspection, better maintenance of mechanical equipment and electrical circuits, systematic timbering and sounding of roof, greater care in placing of shot holes and handling explosives, and other safe practices and methods of working. These will result in a lower accident rate as well as greater efficiency. If any of these requirements is neglected the result is likely to be increased accident occurrence and decreased efficiency.

ACCIDENT FREQUENCY WITH MECHANICAL LOADING

Tables 1 to 22, inclusive, were compiled from data collected at 22 mines in the northern, central, and southern parts of the State. They give the accident-frequency rates, fatalities, tons per lost-time accident, and method of loading. The tables cover a 12-year operating period in 10 mines, an 11-year period in 1 mine, 9-year in 2 mines, 8-year in 3 mines, 5-year in 4 mines, 4-year in 1 mine, and 3-year in 1 mine. It should be remembered that these tables refer only to accident frequency and do not include severity, also that starting with 1931 the fatal-accident rate for all coal mines of the United States for the first time dropped materially and continued to drop more or less steadily until 1936 when they had the lowest fatality rate in the history of the industry.

Year	Average daily tonnage	Tonnage for the year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accidents	Accident-frequency rate[2]	Fatalities	Method of loading
1926	6,073	1,124,441	1,010	1,510,960	399	2,818	264	2	100 percent hand loading.
1927	6,012	775,596	1,039	1,047,312	332	2,336	317	1	Do.
1928	6,155	564,431	1,112	845,120	203	2,780	240	1	Do.
1929	5,940	1,299,502	1,142	1,955,104	398	3,265	203	5	99 percent hand; 1 percent mechanical, with mobile loaders.
1930	6,025	1,049,079	1,121	1,551,464	285	3,680	183	3	97 percent hand; 3 percent mechanical, with mobile loaders.
1931	6,064	516,956	917	917,000	109	4,742	118	0	20 percent hand; 80 percent mechanical; 44 percent with mobile loaders and 56 percent with pit-car loaders.
1932	4,135	538,578	1,005	964,560	134	4,019	138	2	100 percent mechanical; 58 percent with mobile loaders and 42 percent with pit-car loaders.
1933	4,733	491,390	618	581,520	63	7,799	108	0	100 percent mechanical; 65 percent with mobile loaders and 35 percent with pit-car loaders.
1934	4,679	579,236	565	743,320	82	7,063	110	2	100 percent mechanical; 79 percent with mobile loaders and 21 percent with pit-car loaders.
1935	4,581	679,844	480	859,982	79	8,605	91	0	100 percent mechanical; 86 percent with mobile loaders and 14 percent with pit-car loaders.
1936	4,656	771,346	480	935,483	62	12,441	66	1	100 percent mechanical; 99 percent with mobile loaders and 1 percent with pit-car loaders.
1937	4,767	854,797	529	940,496	60	14,246	63	1	100 percent mechanical loading with mobile loaders.

[1] A is a shaft mine 520 feet deep; No. 6 bed; average thickness 9 feet 6 inches. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mechanical haulage and loading. This mine operated from Feb. 15, 1926 to Feb. 5, 1927, without a fatality, produced 1,122,878 tons of coal, and worked approximately 1,291,309 man-hours. It operated from May 20, 1932, to June 1, 1934, without a fatality, produced 1,061,443 tons of coal, and worked approximately 1,379,875 man-hours.

[2] Accident-frequency rate used in tables in this paper is based on total number of lost-time accidents (1 day or more lost time) and man-hours of exposure. It is calculated by multiplying total number of lost-time accidents by 1 million and dividing product by the total number of man-hours exposure at the mine. This gives number of lost-time accidents per million man-hours of exposure. Example: Year 1926 in above table--man-hours of exposure, 1,510,960; total number of lost-time accidents, 399. $\frac{399 \times 1{,}000{,}000}{1{,}510{,}960} = 264$ lost-time accidents per million man-hours of exposure.

TABLE 2. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, Mine B[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident frequency rate	Fatalities	Method of loading
1926	4,993	1,233,390	733	1,428,648	286	4,312	200	1	100 percent hand loading.
1927	4,942	588,052	680	647,360	122	4,820	188	0	Do.
1928	5,056	1,016,183	682	1,096,656	213	4,770	194	2	Do.
1929	5,060	850,118	717	963,648	140	6,072	145	1	Do.
1930	5,056	824,072	699	823,316	142	5,803	172	0	Do.
1931	3,491	701,640	681	822,240	59	11,892	71	1	100 percent mechanical loading with pit-car loaders.
1932	3,529	359,985	462	423,038	46	7,825	108	0	Do.
1933	3,416	662,749	467	870,499	74	8,956	85	0	Do.
1934	3,162	721,033	480	915,890	78	9,244	85	0	Do.
1935	3,116	682,310	470	956,381	65	10,497	67	1	Do.
1936	2,238	478,953	285	641,566	51	9,391	79	0	100 percent mechanical; 23 percent with mobile loaders and 77 percent with pit-car loaders.
1937	2,500	614,987	263	551,178	44	13,976	79	2	100 percent mechanical loading with mobile loaders.

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[1] B is a shaft mine 347 feet deep; no. 6 bed; average thickness, 7 feet 7 inches. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mechanical loading and haulage.

This mine operated from May 27, 1931, to May 13, 1935, without a fatality, produced 2,441,854 tons of coal, and worked approximately 2,736,982 man-hours.

and tons per lost-time
accidents for hand and mechanical loading, mine C[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1929	7,034	1,329,483	1,024	1,366,160	275	4,834	201	0	100 percent hand loading
1930	6,803	959,246	1,053	1,147,568	202	4,748	176	0	Do.
1931	6,990	859,849	1,036	1,076,272	94	9,147	87	1	Do.
1932	6,461	756,006	1,039	1,007,224	98	7,714	97	0	Do.
1933	5,743	964,875	970	1,302,432	105	9,189	80	1	Do.
1934	5,634	890,270	931	1,108,779	110	8,093	99	3	Do.
1935	4,859	635,932	881	975,128	65	9,768	66	1	26 percent hand loading; 74 percent mechanical loading, with mobile loaders.
1936	4,883	1,035,178	882	1,209,203	82	12,624	67	2	5 percent hand loading 95 percent mechanical loading, with mobile loaders.
1937	5,393	1,105,554	797	1,105,648	76	14,546	68	2	100 percent mechanical loading with mobile loaders.

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[1] C is a shaft mine 310 feet deep; No. 6 bed; average thickness 9 feet. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mechanical loading and haulage.
This mine operated from Aug. 6, 1928, to Sept. 28, 1931, without a fatality, produced 3,756,525 tons, and worked approximately 4,618,632 man-hours.

TABLE 4. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine D[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1930	1,703	178,712	249	233,932	33	4,702	143	0	100 percent mechanical loading with pit-car loaders.
1931	1,784	214,157	264	285,120	39	5,491	136	0	Do.
1932	2,017	262,237	285	333,450	52	5,043	155	0	Do.
1933	2,094	253,402	318	364,302	41	6,180	112	0	Do.
1934	2,019	323,141	323	431,851	57	5,669	131	0	100 percent mechanical loading; 89 percent with pit-car loaders, 11 percent with mobile loaders.
1935	1,960	356,788	320	465,920	72	4,955	154	0	100 percent mechanical loading; 83 percent with pit-car loaders, 17 percent with mobile loaders.
1936	2,201	418,263	350	532,000	74	5,652	139	1	100 percent mechanical loading; 53 percent with pit-car loaders, 47 percent with mobile loaders.
1937	2,345	450,313	350	538,353	52	8,659	96	0	100 percent with mechanical loading; 2 percent with pit-car loaders, 98 percent with mobile loaders.

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[1] D is a shaft mine 465 feet deep; No. 5 bed; average thickness, 5 feet 6 inches. Coal bed worked on room-and-pillar panel system; coal undercut before blasting. Mechanical loading and haulage.
This mine operated from Mar. 2, 1929, to July 23, 1936, without a fatality, produced 2,017,536 tons of coal, and worked approximately 2,336,489 man-hours.

accidents for hand and mechanical loading, mine E[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1929	5,936	1,448,364	720	1,264,136	430	3,368	340	9	21 percent hand; 79 percent mechanical; 58 percent with mobile loaders, 42 percent with pit-car loaders.
1930	6,717	940,483	795	1,044,386	240	3,918	229	3	2 percent hand; 98 percent mechanical; 69 percent with mobile, 31 percent with pit-car loaders.
1931	6,746	936,785	785	1,053,883	113	8,290	107	0	100 percent mechanical; 70 percent with mobile, 30 percent with pit-car loaders.
1932	6,411	698,870	630	819,504	71	9,843	86	0	100 percent mechanical; 74 percent with mobile, 26 percent with pit-car loaders.
1933	5,549	559,357	575	683,612	45	12,430	65	0	100 percent mechanical; 94 percent mobile, 6 percent with pit-car loaders.
1934	5,441	887,197	612	814,207	61	14,544	74	2	100 percent mechanical, with mobile loaders.
1935	5,873	1,209,929	620	1,118,416	65	18,614	58	1	Do.
1936	6,484	1,063,545	586	1,079,904	43	24,733	39	0	Do.
1937	6,761	1,054,860	595	980,416	44	23,974	44	0	Do.

[1] E is a shaft mine 417 feet deep; No. 6 bed; average thickness, 9 feet 6 inches. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mechanical loading and haulage. This mine operated from Dec. 5, 1930, to Dec. 7, 1934, without a fatality, produced 3,084,565 tons of coal, and worked approximately 3,154,605 man-hours. It also operated from June 13, 1935, to Jan. 31, 1938, without a fatality, produced 2,843,615 tons of coal, and worked approximately 2,443,903 man-hours.

TABLE 6. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine F[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1933	3,283	620,555	660	915,624	86	7,215	93	0	Hand loading.
1934	2,839	352,067	647	534,835	49	7,185	91	0	Do.
1935	2,686	351,952	622	515,599	47	7,488	91	0	Do.
1936	2,740	394,616	578	539,042	41	9,624	76	1	Do.
1937	2,368	253,421	591	370,650	27	9,385	72	2	Do.

[1] F is a shaft mine 320 feet deep; No. 5 bed; average thickness 5 feet 4 inches. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mule and locomotive haulage. Hand loading.

TABLE 7. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine G[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1933	2,399	271,153	373	309,728	40	6,778	129	4	100 percent hand loading.
1934	2,476	272,405	426	303,645	24	11,350	79	0	Do.
1935	2,462	292,979	424	304,325	32	9,155	105	0	Do.
1936	1,700	282,225	336	294,512	34	8,300	115	0	100 percent mechanical, with mobile loaders.
1937	1,943	36,128	336	35,536	2	18,064	56	0	Do.

[1] G is a shaft mine 243 feet deep; No. 5 bed; average thickness 5 feet. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mechanical haulage and loading.

rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine H[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accident	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1926	2,251	261,178	434	402,752	71	3,678	176	0	100 percent hand loading.
1927	4,283	484,046	679	613,816	120	4,033	195	0	Do.
1928	4,766	1,010,420	703	1,192,523	261	3,871	218	0	Do.
1929	4,678	757,951	620	803,520	145	5,227	180	0	Do.
1930	3,572	753,792	627	857,162	137	5,502	160	1	25 percent hand loading; 75 percent mechanical loading with pit-car loaders.
1931	3,490	589,962	609	723,516	55	10,726	76	1	100 percent mechanical loading with pit-car loaders.
1932	3,342	334,212	486	411,416	43	7,772	104	0	Do.
1933	3,211	597,343	461	342,433	70	8,533	83	1	Do.
1934	3,109	726,125	472	925,128	70	10,373	75	1	Do.
1935	3,111	682,310	470	827,134	77	8,861	93	0	Do.
1936	3,083	857,108	482	1,062,934	67	12,792	63	0	Do.
1937	2,391	432,831	293	497,649	47	9,209	94	0	100 percent mechanical loading; 75 percent with pit-car loaders, 25 percent with mobile loaders.

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[1] H is a shaft mine 338 feet deep; No. 6 bed; average thickness 7 feet 5 inches. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mechanical haulage and loading.
This mine operated from Jan. 11, 1924, to May 1, 1930, without a fatality, produced 3,401,653 tons of coal, and worked approximately 4,041,579 man-hours. It also operated from Dec. 26, 1934, to Jan. 2, 1937, without a fatality, produced 1,548,790 tons of coal, and worked approximately 1,663,328 man-hours.

TABLE 9. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine I[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1926	6,221	1,424,697	1,047	1,918,104	386	3,690	201	7	100 percent hand loading.
1927	6,163	523,866	909	618,123	103	5,086	166	0	Do.
1928	5,106	699,606	548	816,000	148	4,727	131	0	86 percent hand; 14 percent mechanical; with pit-car loaders.
1929	4,234	1,050,000	628	1,401,396	184	5,706	131	1	100 percent mechanical loading with pit-car loaders.
1930	4,339	863,455	693	1,010,808	106	8,145	104	3	Do.
1931	4,193	725,457	649	886,582	85	8,534	95	1	Do.
1932	4,091	249,534	556	305,897	24	10,397	78	0	Do.
1933[2]	------	---------	-------	---------	----	-------	-------	----	------------------------------
1934	1,257	76,684	249	142,112	7	10,954	49	0	100 percent mechanical loading with pit-car loaders.
1935	1,644	369,943	293	548,858	49	7,549	89	0	Do.
1936	2,601	660,662	451	978,832	76	8,692	77	0	Do.
1937	3,386	761,786	602	1,197,481	102	7,468	85	1	Do.

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[1] I is a shaft mine 314 feet deep; No. 6 bed; average thickness, 7 feet. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mechanical haulage and loading.
This mine operated from Nov. 28, 1931, to Apr. 28, 1937, without a fatality, produced 1,674,998 tons of coal, and worked approximately 2,134,365 man-hours.

[2] Mine not working.

accidents for hand and mechanical loading, mine J1/

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1933	1,928	347,113	388	459,163	54	6,428	117	1	Hand loading.
1934	2,011	335,957	428	472,214	48	6,999	101	0	Do.
1935	1,974	359,423	423	473,361	59	6,091	123	4	Do.
1936	1,982	415,551	403	543,732	57	7,290	104	2	Do.
1937	2,025	291,667	403	396,130	21	13,888	53	0	Do.

1/ J is a shaft mine 410 feet deep; No. 5 bed; average thickness 4 feet 10 inches. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mule and locomotive haulage. Hand loading.

TABLE 11. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine K1/

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1934	1,375	305,623	396	396,165	32	9,550	80	0	Hand loading.
1935	2,040	412,156	403	517,965	58	7,106	111	0	Do.
1936	2,034	408,473	424	508,725	60	6,807	117	1	Do.
1937	1,375	159,407	424	234,710	10	15,940	42	0	Do.

1/ K is a shaft mine 412 feet deep; No. 5 bed; average thickness 4 feet 11 inches. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mule and locomotive haulage. Hand loading.

TABLE 12. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine L[1/]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Method of loading
1926	5,865	1,061,629	924	1,337,962	195	5,444	145	3	100 percent hand loading.
1927	5,905	602,304	850	814,558	204	2,952	250	1	Do.
1928	5,795	596,963	851	701,224	155	3,851	221	2	92 percent hand; 8 percent mechanical, with mobile loaders.
1929	4,690	811,442	819	1,133,496	139	5,837	122	1	23 percent hand; 77 percent mechanical; 63 percent with mobile, 37 with pit-car loaders.
1930	5,301	764,645	564	829,110	42	18,205	50	5	100 percent mechanical; 58 percent with mobile loaders, 42 percent with pit-car loaders.
1931	6,137	699,662	558	715,833	54	12,956	75	0	100 percent mechanical; 68 percent mobile, 32 percent pit-car loaders.
1932	6,769	710,761	543	601,920	38	18,704	63	1	100 percent mechanical; 79 percent with mobile, 21 percent with pit-car loaders.
1933	6,596	725,606	506	623,242	59	12,298	94	1	100 percent mechanical; 97 percent mobile, 3 percent pit-car loaders.
1934	6,600	877,871	516	685,914	18	48,770	26	2	100 percent mechanical loading with mobile loaders.
1935	7,095	776,987	534	625,949	8	97,123	12	0	Do.
1936	7,325	1,108,109	557	784,108	19	58,321	24	0	Do.
1937	7,469	1,109,723	569	798,307	28	39,632	35	0	Do.

[1/] L is a shaft mine 600 feet keep; No. 6 bed; average thickness, 7 feet 6 inches. Coal bed worked on room-and-pillar panel system; coal undercut before blasting. Mechanical haulage and loading. This mine operated from July 6, 1934, to June 1, 1938, without a fatality, produced 3,822,396 tons of coal, and worked approximately 2,245,637 man-hours.

per lost-time
accidents for hand and mechanical loading, mine M[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1926	2,583	405,551	530	406,988	68	5,963	167	0	Hand loading
1927	2,767	185,400	529	175,564	31	5,980	176	0	Do.
1928	1,991	131,407	465	146,393	22	5,973	150	0	Do.
1929	2,930	313,584	465	281,960	58	5,406	205	0	Do.
1930	2,892	153,316	442	183,321	23	6,665	125	1	Do.
1931	2,860	306,021	430	284,623	61	5,016	214	1	22 percent hand loading; 78 percent mechanical, with mobile loaders.
1932	3,267	431,332	312	351,127	36	11,981	102	1	9 percent hand loading; 91 percent mechanical, with mobile loaders.
1933	3,600	597,638	311	441,567	43	13,898	97	2	8 percent hand loading; 92 percent mechanical, with mobile loaders.
1934	3,263	440,637	330	359,104	38	11,595	105	0	9 percent hand loading; 91 percent mechanical, with mobile loaders.
1935	3,461	574,630	318	443,580	37	15,530	83	0	Do.
1936	3,707	697,006	370	500,085	36	19,361	71	2	10 percent hand loading; 90 percent mechanical, with mobile loaders.
1937	3,434	665,532	319	502,775	25	26,621	49	0	6 percent hand loading; 94 percent mechanical, with mobile loaders.

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[1] M is a shaft mine about 200 feet deep; No. 6 bed; average thickness 7 feet 6 inches. Coal bed worked on a room-and-pillar panel system. Mechanical haulage. Hand and mechanical loading.

This mine operated from Sept. 25, 1925, to Oct. 17, 1930, without a fatality, produced 1,361,388 tons of coal, and worked approximately 1,499,323 man-hours. It also operated from Sept. 25, 1933, to Dec. 28, 1936, without a fatality, produced 1,345,898 tons of coal, and worked approximately 1,401,906 man-hours.

TABLE 14. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine N[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1926	9,887	2,471,761	1,643	3,286,000	676	3,656	205	11	96 percent hand loading; 4 percent mechanical, with mobile loaders.
1927	11,582	1,528,888	1,902	2,008,512	403	3,793	200	1	95 percent hand loading; 5 percent mechanical, with mobile loaders.
1928	10,262	2,411,572	1,761	3,310,680	698	3,454	210	7	74 percent hand loading; 26 percent mechanical, with mobile loaders.
1929	10,085	1,952,327	1,244	2,164,358	292	6,686	134	2	25 percent hand loading; 75 percent mechanical; 78 percent with mobile loaders, 22 percent with pit-car loaders.
1930	9,829	1,739,653	1,225	1,834,600	175	9,940	95	2	100 percent with mechanical loading; 68 percent with mobile loaders; 32 percent with pit-car loaders.
1931	9,979	1,556,660	1,224	1,637,344	191	8,150	116	1	100 percent mechanical; 71 percent with mobile loaders; 29 percent with pit-car loaders.
1932	10,407	1,061,578	1,198	1,067,568	100	10,615	93	4	100 percent mechanical; 72 percent with mobile loaders; 28 percent with pit-car loaders.
1933	9,093	892,865	1,020	899,584	106	8,423	117	4	100 percent mechanical; 81 percent with mobile loaders; 19 percent with pit-car loaders.
1934	9,072	1,206,619	1,051	1,344,442	84	14,364	62	2	100 percent mechanical; 86 percent with mobile loaders, 14 percent with pit-car loaders.
1935	9,252	1,387,812	930	1,477,049	93	14,922	62	2	100 percent mechanical; 88 percent with mobile loaders, 12 percent with pit-car loaders.
1936	9,170	1,485,604	936	1,659,923	85	17,477	51	4	100 percent mechanical; 96 percent with mobile loaders, 4 percent with pit-car loaders.
1937	9,361	1,562,343	948	1,642,211	90	17,359	54	3	100 percent mechanical; 98 percent with mobile loaders, 2 percent with pit-car loaders.

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[1] N is a shaft mine 491 feet deep; No. 6 bed; average thickness, 9 feet. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mechanical loading and haulage. This mine operated from July 22, 1929, to Sept. 10, 1930, without a fatality, produced 2,096,072 tons of coal, and worked 2,200,875 man-hours.

accidents for hand and mechanical loading, mine O1/

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1927	4,898	597,598	751	732,796	246	2,429	335	0	100 percent hand loading.
1928	3,487	697,582	489	782,400	238	2,422	363	2	50 percent hand; 50 percent mechanical, with mobile loaders.
1929	3,526	719,345	387	710,535	271	2,654	381	1	100 percent mechanical loading, with mobile loaders.
1930	4,473	988,617	397	789,642	231	4,279	292	2	Do.
1931	4,624	1,008,199	403	790,632	191	5,278	241	2	Do.
1932	4,245	475,442	412	415,296	67	7,096	161	2	Do.
1933	4,065	747,979	396	655,766	112	6,673	170	0	Do.
1934	3,850	789,442	399	736,155	136	5,804	184	0	Do.
1935	3,614	722,832	399	628,400	42	17,210	66	0	Do.
1936	3,713	779,752	408	685,440	52	14,995	75	2	Do.
1937	3,730	496,108	415	442,560	55	9,020	124	1	Do.

1/ O is a shaft mine 375 feet deep; No. 6 bed; average thickness, 7 feet 6 inches. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mechanical haulage and loading.
This mine operated from Feb. 13, 1932, to Jan. 3, 1936, without a fatality, produced 2,233,761 tons of coal, and worked 2,554,550 man-hours.

TABLE 16. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine P[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accidents	Accident-frequency rate	Fatalities	Methods of loading
1930	1,712	298,268	398	494,312	72	4,142	145	0	100 percent hand loading.
1931	2,320	310,997	406	463,784	82	3,792	176	1	Do.
1932	403	6,862	138	18,768	2	3,431	106	0	Do.
1933	1,107	248,158	312	425,960	69	3,596	161	0	Do.
1934	1,634	295,886	378	450,443	57	5,190	126	0	Do.
1935	2,123	426,908	356	542,213	60	7,115	110	0	93 percent hand; 7 percent mechanical, with mobile loaders.
1936	2,244	477,554	337	550,137	45	10,612	81	1	78 percent hand; 22 percent mechanical, with mobile loaders.
1937	2,273	447,910	353	502,928	41	10,924	81	0	72 percent hand; 28 percent mechanical, with mobile loaders.

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[1] P is a slope mine 46 feet deep; No. 5 bed; average thickness 4 feet 4 inches. Coal bed worked on room-and-pillar panel system; coal undercut before blasting. Locomotive and mule haulage. Both hand and mechanical loading

This mine operated from Aug. 24, 1931, to Aug. 8, 1936, without a fatality, produced 1,297,550 tons of coal, and worked approximately 1,865,840 man-hours.

7043

rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine Q1/

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading.
1930	2,112	285,170	392	471,484	78	3,656	165	0	Hand loading.
1931	2,815	512,374	439	720,734	119	4,305	165	0	Do.
1932	2,944	420,906	552	558,616	87	4,838	155	2	Do.
1933	3,398	744,516	599	1,025,680	131	5,683	127	1	Do.
1934	3,326	785,092	567	1,022,711	136	5,772	132	1	Do.
1935	3,089	611,693	536	770,931	77	7,944	99	1	Do.
1936	3,299	653,330	506	761,348	68	9,607	89	1	Do.
1937	3,353	563,321	506	649,775	54	10,431	83	1	Do.

1/ Q is a slope mine 70 feet deep; No. 5 bed; average thickness, 4 feet 4 inches. Coal bed worked on a room-and-pillar panel system; coal undercut before blasting. Mule and locomotive haulage.

TABLE 18. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine R1/

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1933	2,993	461,014	570	758,832	164	2,811	216	0	100 percent hand loading.
1934	2,823	400,910	577	643,833	98	4,909	152	0	Do.
1935	2,552	461,990	529	685,556	123	3,755	179	1	2 percent mechanical, with mobile loaders; 98 percent hand loaders.
1936	1,742	385,009	207	490,035	93	4,139	189	2	61 percent mechanical, with mobile loaders; 39 percent hand loading.
1937	1,847	385,832	237	483,909	68	5,674	140	2	100 percent mechanical loading with mobile loaders.

1/ R is a shaft mine 325 feet deep; No. 5 bed; average thickness, 5 feet 6 inches. Coal bed worked on room-and-pillar panel system; coal undercut before blasting. Mechanical haulage and loading.
This mine operated from June 19, 1931, to Mar. 18, 1935, without a fatality, produced 1,439,446 tons of coal, and worked approximately 1,629,097 man-hours.

TABLE 19. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine S[1/]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1935	741	26,682	172	52,493	9	2,964	171	0	100 percent hand loading.
1936	1,097	173,437	247	255,024	41	4,230	160	0	Do.
1937	1,167	157,421	249	234,570	35	4,497	149	0	Do.

1/ S is a slope mine 50 feet deep; No. 5 bed; average thickness, 4 feet 8 inches. Coal bed worked on room-and-pillar panel system; coal undercut before blasting. Mechanical haulage and loading.

TABLE 20. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine T[1/]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1926	3,328	709,042	675	1,150,200	168	4,220	146	6	Hand loading.
1927	3,525	447,754	672	682,752	92	4,866	134	1	Do.
1928	3,470	628,093	700	1,013,600	121	5,190	119	1	Do.
1929	3,495	796,919	720	1,313,280	168	4,743	127	1	Do.
1930	3,403	707,895	640	1,064,960	146	4,848	137	3	Do.
1931	3,153	498,747	659	817,160	102	4,889	124	0	Do.
1932	3,413	389,107	635	579,120	56	6,948	96	0	Do.
1933	3,235	414,189	616	630,784	50	8,283	79	0	Do.
1934	3,037	391,819	571	515,613	44	8,904	85	0	96 percent hand loading; 4 percent mechanical with pit-car loaders.
1935	2,665	487,803	567	601,584	67	7,280	111	2	55 percent hand; 45 percent mechanical; 76 percent mobile loaders, 24 percent with pit-car loaders.
1936	3,131	626,307	541	686,295	61	10,267	88	0	26 percent hand; 74 percent mechanical; 82 percent mobile, 18 percent pit-car loaders.
1937	3,309	569,254	550	626,385	59	9,648	94	0	15 percent hand; 85 percent mechanical; 86 percent mobile, 14 percent with pit-car loaders.

1/ T is a shaft mine 365 feet deep; No. 6 bed; average thickness, 9 feet 6 inches. Coal bed worked on room- coal undercut before blasting. Mule and locomotive haulage. Mechanical and to Jan. 3, 1938, without a fatality, produced and mechanical loading, mine U[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1926	4,073	863,519	730	1,238,080	293	2,947	236	2	Hand loading
1927	4,254	570,084	734	840,448	167	3,413	198	0	Do.
1928	4,009	817,997	704	1,148,828	231	3,541	201	3	76 percent hand; 24 percent mechanical, with mobile loaders.
1929	4,299	821,188	780	1,191,840	285	2,881	239	1	40 percent hand; 60 percent mechanical, with mobile loaders.
1930	3,353	546,576	593	773,272	122	4,480	157	0	31 percent hand; 69 percent mechanical, 30 percent mobile and 70 percent with pit-car loaders.
1931	3,214	588,362	638	934,032	101	5,825	108	2	16 percent hand; 84 percent mechanical, 33 percent mobile and 67 percent with pit-car loaders.
1932	3,147	443,825	628	708,384	78	5,690	110	0	12 percent hand; 88 percent mechanical, 33 percent mobile and 67 percent with pit-car loaders.
1933	3,185	423,763	583	620,312	75	5,650	120	0	15 percent hand; 85 percent mechanical; 53 percent mobile, 47 percent with pit-car loaders.
1934	2,885	519,446	550	693,000	64	8,116	92	1	44 percent hand; 56 percent mechanical; 88 percent mobile, 12 percent with pit-car loaders.
1935	3,158	505,910	575	519,765	57	8,875	109	1	30 percent hand; 70 percent mechanical with mobile loaders.
1936	3,511	516,122	535	512,778	38	13,582	74	0	12 percent hand; 88 percent mechanical; 94 percent mobile, 6 percent pit-car loaders.
1937	3,975	624,152	506	545,707	28	22,291	51	1	6 percent hand; 94 percent mechanical; 90 percent mobile, 10 percent with pit-car loaders.

[1] U is a shaft mine 315 feet deep; No. 6 bed; average thickness, 9 feet 6 inches. Coal bed worked on room-and-pillar panel system; coal undercut before blasting. Mechanical haulage. Hand and mechanical loading. This mine operated from Aug. 12, 1931, to Oct. 18, 1934, without a fatality, produced 1,510,147 tons of coal, and worked approximately 2,253,085 man-hours.

TABLE 22. - Accident-frequency rates, fatalities, and tons per lost-time accidents for hand and mechanical loading, mine V[1]

Year	Average daily tonnage	Tonnage for year	Average number of men employed	Man-hours of exposure	Lost-time accidents	Tons per lost-time accident	Accident-frequency rate	Fatalities	Methods of loading
1926	4,362	1,090,581	779	1,558,000	220	4,957	141	0	100 percent hand loading.
1927	3,719	409,075	545	479,600	74	5,528	154	0	Do.
1928	2,297	523,703	389	798,216	92	5,692	115	0	17 percent hand; 83 percent mechanical, with pit-car loaders.
1929	3,045	736,797	400	871,200	107	6,886	122	0	100 percent mechanical, with pit-car loaders.
1930	3,190	612,549	433	714,175	79	7,753	110	0	Do.
1931	3,189	497,420	429	600,518	40	12,435	66	1	Do.
1932	3,216	236,198	431	350,573	24	11,924	68	0	Do.
1933	3,211	597,343	461	821,437	43	13,891	52	0	Do.
1934	2,958	662,606	447	837,872	51	12,992	60	2	Do.
1935	1,644	369,943	293	759,617	52	7,114	68	0	Do.
1936	2,678	672,204	463	910,438	60	11,203	65	1	Do.
1937	2,097	354,389	303	464,549	39	9,036	83	0	100 percent mechanical; 30 percent with mobile, 70 percent with pit-car loaders.

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[1] V is a shaft mine 338 feet deep; No. 6 bed; average thickness, 7 feet 5 inches. Coal bed worked on room-and-pillar panel system; coal undercut before blasting. Mechanical loading and haulage.

This mine operated from Jan. 3, 1925, to May 1, 1931, without a fatality, produced 4,580,911 tons of coal, and worked **approximately** 5,710,631 man-hours.

COMPARISON OF ACCIDENT FREQUENCY WITH HAND AND MECHANICAL LOADING

Accident-frequency rates for hand and mechanical loading should be compared only in mines that have changed from 100 percent hand to 100 percent mechanical loading; again attention is called to the fact that accident severity is not discussed. A study of such mines in tables 1 to 22, inclusive, shows that frequency rates are decidedly lower in mines with 100-percent mechanical loading than in those with 100-percent hand loading or partial hand loading. However, it must be recognized that in almost every mine studied there were other causes that had a vital effect on reduction of accident rates, such as a definite increase in safety work, giving of safety bonuses, more or less universal first-aid training, etc. Safety procedure greatly increased and was more effective not only in the mines undergoing mechanization but also in nonmechanized mines and reductions in accident frequency and severity were fairly definite in nonmechanized mines, not only in Illinois but in other States from 1925 (and more particularly from 1930) to date. Some of the largest reductions in frequency rates are as follows:

Table 1, Mine A

The average frequency rate for this mine for the 3 years 1926-28, with 100 percent hand loading, is 274 and for the 3 years 1935-37, with 100 percent mechanical loading, 73, a reduction of 73.3 percent in favor of mechanical Loading. The highest frequency rate with 100 percent hand loading is 317 for 1927, and the lowest is 240 for 1928. The highest frequency rate with 100 percent mechanical loading is 138 for 1932 and the lowest is 63 for 1937.

Table 2, Mine B

The average frequency rate for this mine for the 3 years 1928-30, with 100 percent hand loading, is 170.3 and for the 3 years 1935-37, with 100 percent mechanical loading, 75, a reduction of 55.9 percent in favor of 100 percent mechanical loading. The highest frequency rate with 100 percent hand loading is 200 for 1926, and the lowest is 145 for 1929. The highest frequency rate with 100 percent mechanical loading is 108 for 1932, and the lowest is 67 for 1935.

Table 8, Mine H

The average frequency rate for this mine for the 3 years 1927-29, with 00 percent hand loading, is 197.6 and for the 3 years 1935-37, with 100 ercent mechanical loading, 83.3, a reduction of 57.8 percent in favor of echanical loading for the 3 years. The highest frequency rate with 100 ercent hand loading is 218 for 1928, and the lowest is 180 for 1929. The ighest frequency rate with 100 percent mechanical loading is 104 for 1932, nd the lowest is 63 for 1936.

Table 9, Mine I

The average frequency rate for this mine for the 2 years 1927-28, with 100 percent hand loading, is 183.5 and for the 2 years 1936-37, with 100 percent mechanical loading, 81, a reduction of 55.8 percent in favor of mechanical loading for the period. The highest frequency rate with 100 percent hand loading is 201 for 1928, and the lowest is 166 for 1927. The highest frequency rate with 100 percent mechanical loading is 131 for 1929, and the lowest is 49 for 1934.

Table 12, Mine L

The average frequency rate for this mine for the 2 years 1926-27, with 100 percent hand loading, is 197.5 and for the 2 years 1936-37, with 100 percent mechanical loading, 29.5, a reduction of 85 percent in favor of 100 percent mechanical loading. The highest frequency rate with 100 percent hand loading is 250 for 1927, and the lowest is 145 for 1926. The highest frequency rate with 100 percent mechanical loading is 94 for 1933, and the lowest is 12 for 1935 (the lowest frequency rate listed in the 22 tables).

Table 22, Mine V

The average frequency rate for this mine for the 2 years 1926-27, with 100 percent hand loading, is 147.5 and for the 2 years 1936-37, with 100 percent mechanical loading, 74, a reduction of 49.7 percent in favor of mechanical loading. The highest frequency rate with 100 percent hand loading is 154 for 1927, and the lowest is 141 for 1926. The highest frequency rate with 100 percent mechanical loading is 122 for 1929, and the lowest is 52 for 1933.

Tables 23 to 26 are composite tables compiled from data on the 22 mines. These tables are grouped as follows: 100 percent hand loading, 50 to 99 percent hand loading, 1 to 50 percent hand loading, and 100 percent mechanical loading. The tables show, for each period, the total number of lost-time and fatal injuries and their frequency rates, the tonnage per lost-time and fatal injury, and the man-hours of exposure per lost-time and fatal injury, and the man-hours of exposure per lost-time and fatal injury.

Table 23 represents 75 mine-years of operation with 100 percent hand loading. This table shows a lost-time injury frequency rate of 156 and a fatality frequency rate of 1.16.

Total tonnage produced	Total man-hours of exposure	Total lost-time accidents	Lost-time accident frequency rate	Tonnage per lost-time accident	Man-hours of exposure per lost-time accident	Fatalities	Tonnage produced per fatality	Man-hours of exposure per fatality	Fatality frequency rate
40,974,519	53,034,930	8,314	156	4,928	6,378	62	660,879	855,402	1.16

TABLE 24. - 50 to 99 percent hand loading, 1 to 50 percent mechanical loading (represents 14 mine-years of operation)

12,497,328	18,142,243	3,569	196	3,501	5,083	38	328,877	477,427	2.09

TABLE 25. - 1 to 50 percent hand loading, 50 to 99 percent mechanical loading (represents 30 mine-years of operation)

19,574,593	22,307,625	3,130	140	6,253	7,127	33	593,169	675,988	1.47

TABLE 26. - 100 percent mechanical loading (represents 81 mine-years of operation)

56,874,445	62,962,757	5,848	92	9,725	10,766	73	779,101	862,503	1.15

Table 24 represents 14 mine-years of operation with 50 to 99 percent hand loading or 1 to 50 percent mechanical loading and might be termed the "first transition period." The lost-time injury frequency rate is 196 (25.6 percent higher than that for 100 percent hand loading). The fatality frequency rate is 2.09 (71.5 percent higher than that for 100 percent hand loading). The tonnage produced per fatality, the lost-time **injury fre**quency rate, the man-hours of exposure, and tonnage produced per lost-time injury are less than that for 100 percent hand loading. Doubtless the increase in the accident rate of the transition period, as shown in table 24, is due largely to lack of knowledge by both management and employees regarding the maintenance, operation, and safe methods of working and moving equipment at the face and from place to place. It is believed that tables 25 and 26 verify this statement.

Table 25 represents 30 mine-years of operation with 1 to 50 percent hand loading or 50 to 99 percent mechanical loading and might be termed the "second transition period." The lost-time injury frequency rate is 140 (10.2 percent lower than that for 100 percent hand loading). The fatality frequency rate is a fraction higher than that for 100 percent hand loading. The tonnage produced and the man-hours of exposure per lost-time accident are higher, but the tonnage produced and the man-hours of exposure per fatality are less than that for 100 percent hand loading.

Table 26 represents 81 mine-years of operation with 100 percent mechanical loading. This table shows a frequency rate of 92 (41 percent lower than that for 100 percent hand loading). The fatality frequency rate is 1.15, or a fraction less than that shown in table 23. The tonnage produced and man-hours of exposure are higher in this table that for 100 percent hand loading.

Figure 1 shows the tonnage produced and man-hours of exposure per lost-time accident, in 10-percent graduations, from 100 percent hand loading to 100 percent mechanical loading. The general trend of the graph is downward from 100 percent hand loading, which has 4,928 tons and 6,378 man-hours per lost-time accident, to 50 to 60 percent mechanical loading, which has 2,881 tons and 4,181 man-hours per lost-time accident. From 50 to 60 percent mechanical loading the general trend is upward to 100 percent mechanical loading, which has 9,725 tons and 10,766 man-hours per lost-time accident.

Figure 2 shows the lost-time accident frequency rate, in 10-percent graduations, from 100 percent hand loading to 100 percent mechanical loading. The general trend is upward from 100 percent hand loading, with a frequency rate of 156, to 40 to 50 percent mechanical loading, with a frequency rate of 256. From 40 to 50 percent mechanical loading the general trend is downward to 100 percent mechanical loading, which has a frequency rate of 92.

The information contained in these tables and figures indicates that accident frequency is less with mechanical than with hand loading. However, at least one important factor is involved in the reduction in accident-frequency rates of mines with 100 percent mechanical loading, namely the much greater interest manifested in safety of operation in the past few years by company officials and employees than was ever shown before mechani-

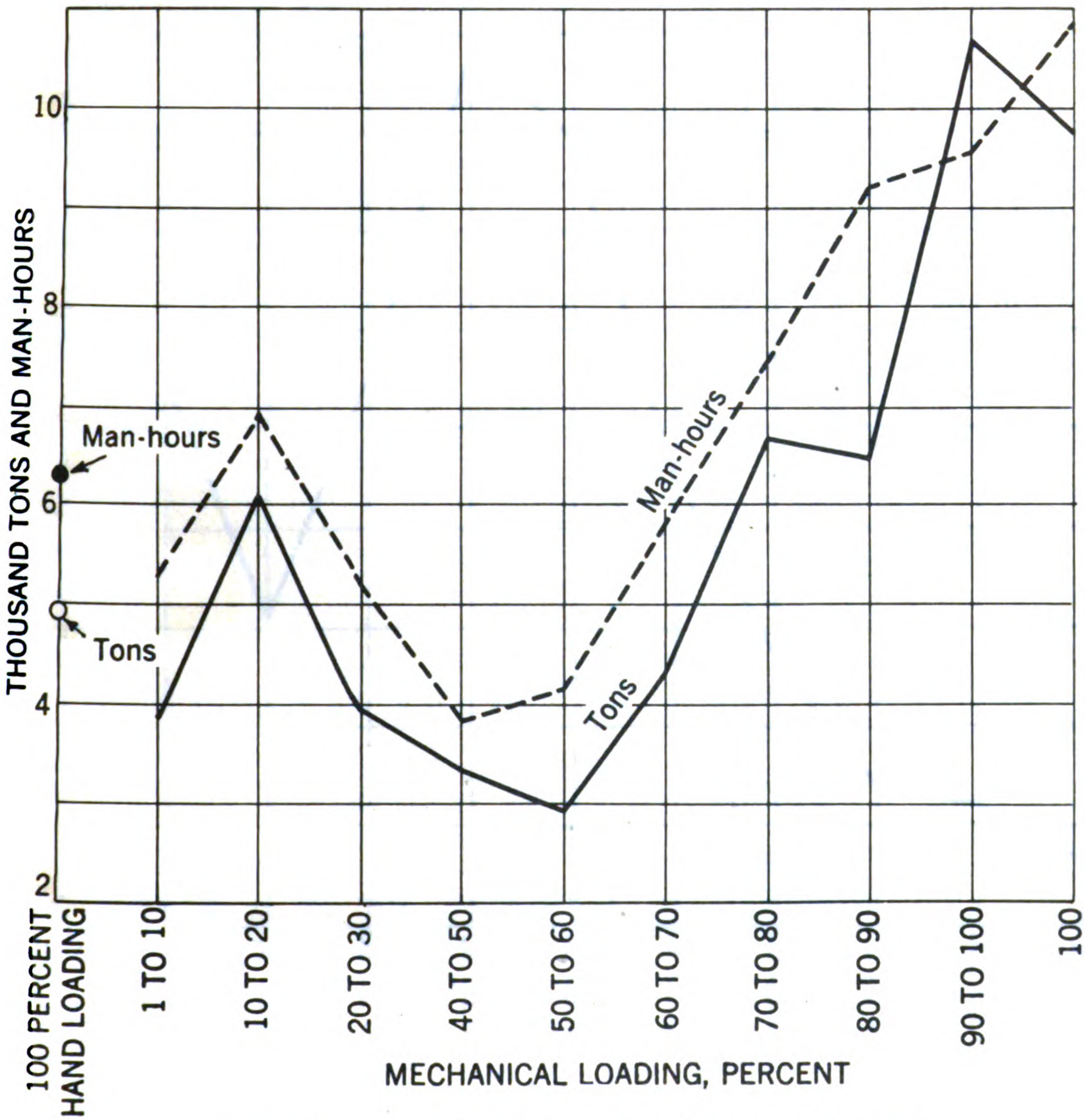

Figure 1.- Tons and man-hours per lost-time accident.

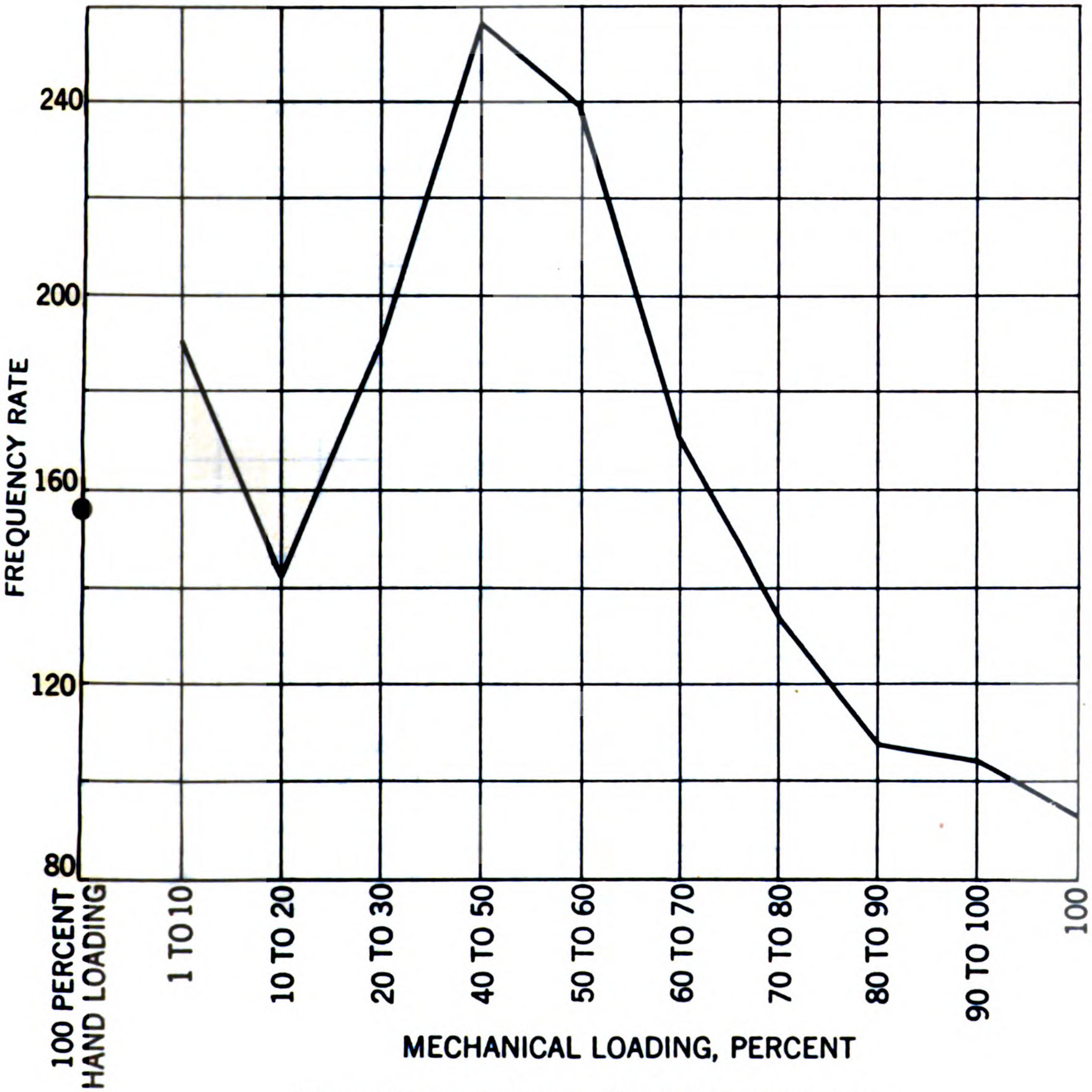

Figure 2.–Lost-time accident-frequency rate.

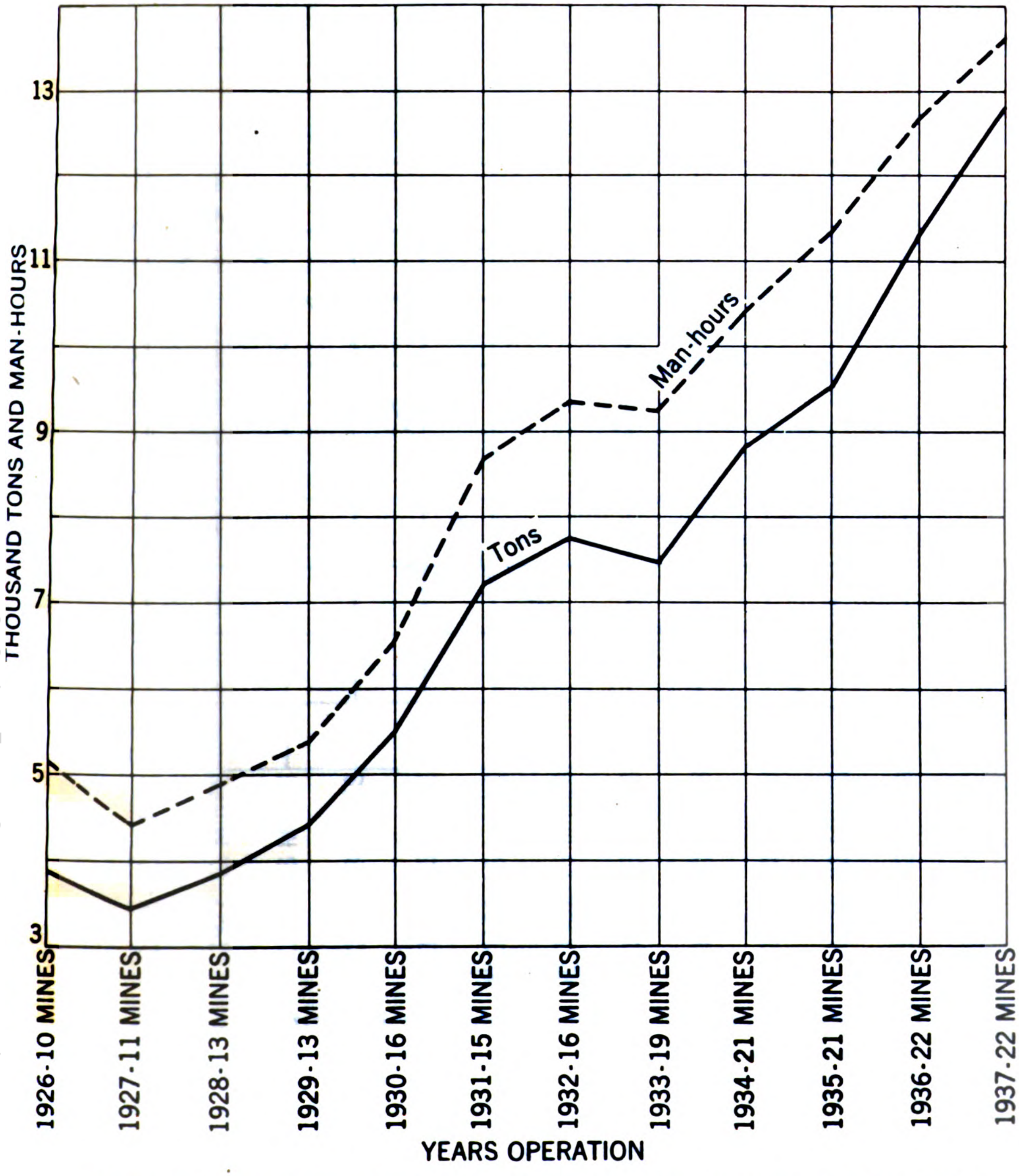

Figure 3.-Tons and man-hours per lost-time accident by years, 1926 to 1937.

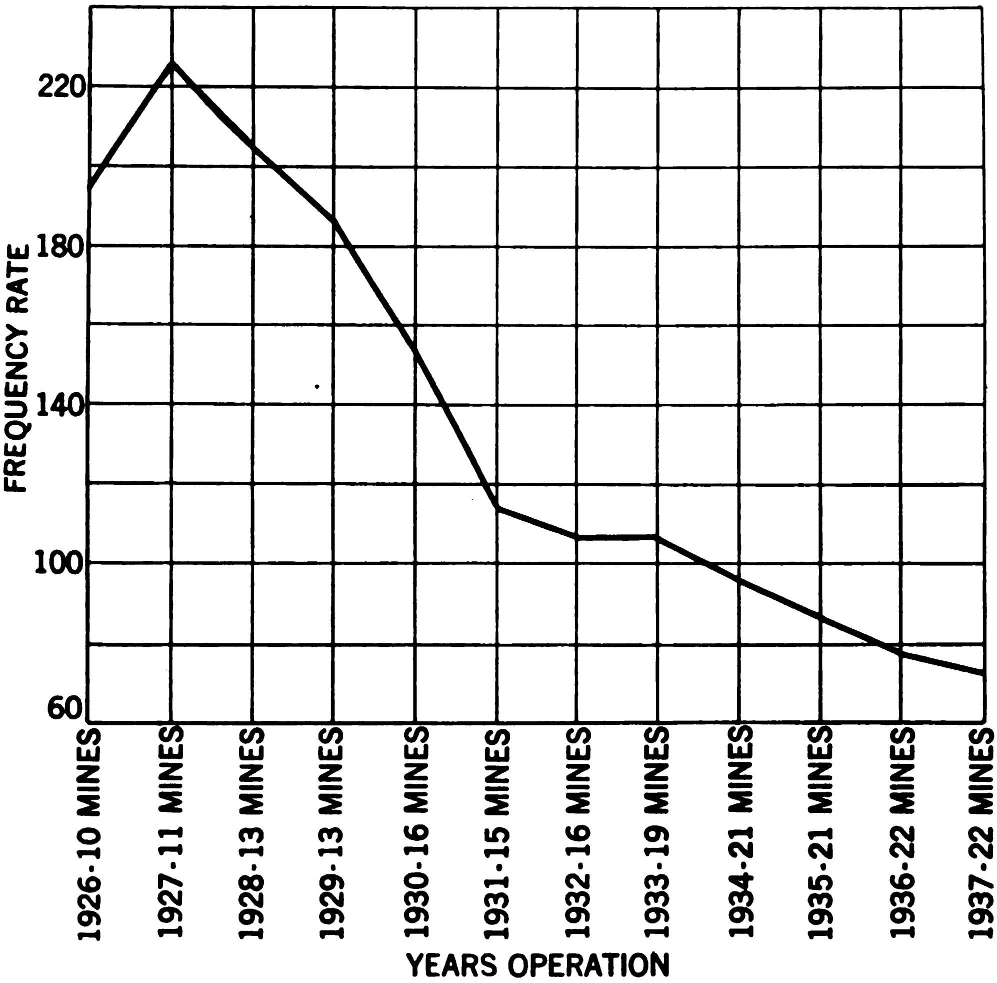

Figure 4.–Lost-time accident-frequency rate by years, 1926 to 1937.

cal loading was introduced. Unquestionably if similar active interest had been manifested before mechanical loading was introduced the accident rate of hand loading would have been very much lower, as the intensified attention to safety (especially first-aid training) started about 1925 or 1926, the starting dates given in most of the tables. However, the reduction in accident-frequency rate with 100 percent mechanical loading indicates what can be done with cooperative effort.

Some mines in the State operating with 100 percent hand loading have made commendable progress in reducing their accident rate in the past few years. Mine Q, table 17, which is a 100 percent hand-loading mine during the 3 years 1935-37 showed a 34.7-percent reduction in frequency rate compared with the 3 years 1932-34. Mine P, table 16, with part hand loading, showed a 31-percent reduction in the frequency rates for the 3 years 1935-37, compared with the 3 years 1932-34.

It should also be emphasized that whether the mines listed used hand or mechanical loading those that have made the greatest progress in reducing their accident frequency and severity rates are those in which both the officials of the companies and the workers have shown an increased interest in safety in the past few years. The writer believes that the State-wide interest manifested in safety today by operators and mine workers began between 1927 and 1930, when some of the larger companies started to take an active interest in safety. Unquestionably their interest curtailed accidents in the years following that period.

Figures 3 and 4 show the tonnage produced, man-hours of exposure, and frequency rates for lost-time accidents by years from 1926 to 1937, inclusive. The figures are based upon the tables regardless of whether the mines used 100 percent hand loading, partial mechanical loading, or 100 percent mechanical loading, and it is believed they show the rates according to the development of interest in safety. In figure 3 the general trend is upward from 1927, with 3,423 tons and 4,416 man-hours per lost-time accident, to 1937, with 12,861 tons and 13,646 man-hours per lost-time accident. In figure 4, which shows the frequency rates per million man-hours worked, the general trend is downward from 1927, with a frequency rate of 226, to 1937, with a frequency rate of 73.

CONCLUSION

This study indicates that regardless of whether hand or mechanical loading is used or how much other mechanical equipment is operated in and around the mines, the accident rate of the industry in the future will be governed by the extent, sincerity, and continuity of effort taken in accident prevention by the coal companies and mine workers.